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Secondary Science (Physics)

Summer Institute 2025: Mongolia

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"Extent of the oceanic Khan from a horseman's perspective"

Motivator: A wise Mongolian phrase:
" It is better to see one time despite of hearing a thousand times"

I hope that this lesson will make the student feel like they have somehow arrived in the historical times of Ikh Mongol and will provide a stronger imprint in their minds for both the physics concepts as well as the Mongol empire.

Organizing/Essential/Guiding Questions:

1. What is the time difference between scientific/technological discoveries between the ancient Asian sources and their European counterparts? How did these discoveries flow from the Asian geography towards the west?
2. What was the impetus that made the silk road such an efficient and safe avenue for the exchange of said ideas?
3. What was the Mongol horseman's contribution to the success of the impetus (per physics alone)

Introduction/ Overview:

This lesson is focused more on a secondary physics class, to be conducted in either the later part of the Fall semester or the middle of the spring semester. This lesson's aim is to review concepts learned in the classical mechanics unit. The lesson is cross-curricular, in that elements of history/social science will be used to solidify the understanding of the physics concepts learned and to make them applicable to real-world application. This lesson is designed to be a springboard for student investigation that will be presented to the physics class at a later time

To begin, a query will be introduced that will make the student realize that the majority of European scientific discoveries were well known by Asian intellectuals long before their western publication. (Example used will be the compass: Kanji symbols for the compass will be discussed and compared with the 1600 announcement by William Gilbert).

Secondly, it will be shown that the extent of the Silk Road's influence on the expediency of discoveries such as these was a direct result of the *Pax Mongolica*.

Thirdly, the contributions to the success *Pax Mongolica* from the physics seen in the individual horsemen of the Mongol empire will be investigated. A short practical exercise will enforce one (or more) of these evidences

Fourthly, an example of a scientific idea that was transcultural will be shown (specifically, the telescope).

Finally, the students will be allowed to participate and make their own conclusions on other transcultural scientific ideas and will present their findings to the class.

Content Standards:

HS-PS2-1 Motion and Stability: Forces and Interactions

Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

HS-PS3-1 Energy

Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

HS-PS3-2 Energy

Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).

HS-PS4-1. Waves

Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media**.**

Objectives: After the lesson, students should be able to:

1. Explain the connection between the Mongol empire and the efficiency of the Silk Road
2. Provide at least three pieces of evidence that shows how a Mongol horseman contributed to the success of the *Pax Mongolica.*
3. Adequately present a scientific topic (one of three formats) that reached the Renaissance period as a direct result of transport along the Silk Road

Materials/Resources:

-Graphic showing Kanji symbols for the term "compass"
-Various visual representations of Mongol horsemen and their weapons of use
-Various visual representations of equations for motion, energy, and sound phenomena.
-Article : Otgonsaikhan Nyamdaa "Silk Road and Trade of the Mongol Empire"
https://doi.org/10.1515/modi-2023-2007

Special Equipment:

-Class set of bows (8 individual crossbows which use the longbow design) (practical exercise)
-Class set of bows (8 individual crossbows which use the Mongol design) (practical exercise)
-8 arrows specifically designed to be used with said crossbows (practical exercise)
-Large fruit (cantaloupe) to be used as a target for crossbows (practical exercise)
-Hanging target for use of thrown projectile (student demonstration)
-Examples of arrows with arrow-heads that whistle (teacher demonstration)

Teacher Preparation:

Practical exercise: Instructor will set up eight (8) stations in classroom in order to compare the longbow design with the Mongol design. A large fruit (cantaloupe) will be used as a target for each station. All shots made with the crossbows will be towards the outer walls for safety. Instructor will distribute bows to each station; collecting items after three shots have been completed. Targets will stay in place (with imbedded arrows) as lesson continues.
Demonstration #1: Two student volunteers will be chosen to throw a projectile at an object, both from the stationary standing position as well as the lateral moving position. Volunteers will be told to throw the projectile (a sticky ball, say) in both positions. It should be noted that a thrown object while the volunteer *is in the air* will hit the target with greater accuracy. After the demonstration, instructor will discuss how Mongol horsemen would release their arrows while their horse is in mid-air so as to maximize accuracy. Instructor will note that this practice of releasing arrows minimizes the errors due to the period where the horse's hooves are not striking the ground.
Demonstration #2: Instructor will have prepared arrows which contain arrowheads that will make a whistling sound when traveling at a high speed (Note: a safer demonstration will be that the instructor will utilize a football toy (NERF) that whistles when thrown. Either demonstration will illustrate the use of psychological operations by the Mongols, in that these sounds made during battle are deceiving; making the Mongols force numbers appear greater.

Time/Timeline: 50.0 to 55.0 minutes for Query investigation/practical exercise/demonstration (instructor)
Additional 10.0 to 15.0 minutes (per student) presentations (approximately 200.0 minutes)
Total time for lesson: approximately 250.0 minutes, or 1.5 weeks.

Procedures:

I. Part One: **Presentation of Essential/Leading Questions**

Instructor will establish the foundation pre-supposition of Mongol dominance in its conquering campaign directly led to the efficient transfer of scientific ideas along the Silk Road.

II. Part Two: **Presentation of Evidence to show contributions of Mongol horseman**

Instructor will present several pieces of evidence to show the physics involved in the combat of said horseman. Specifically, superior bow design, advantageous use of terrain, techniques of arrow release, and psychological effect of whistling arrows.
(Note: the physics concepts include: Energy transfer, Newton's laws, kinematics of motion and sound phenomena)

III. Part Three: **Presentation of Intracultural Scientific Concept**

Instructor will present (as an example) a physics concept whose influence was carried along the Silk Road. Specifically, the discovery and implementation of the telescope. The Mongol connection of this concept will also be discussed (legendary Mongol leader Duva the Blind).

IV. Part IV: **Assignment of research project to students**

Students will now be assigned a research assignment where they will find another scientific concept that traveled along the Silk Road and to find the Mongol connection to said concept. Examples available include (but not limited to): gunpowder, siege weapons, musical instruments, magnetic devices, etc. Students will present their findings to the class at a later date, and will have the option of how they will present their findings.

Student presentations will be in three formats (chosen by students):

1. Public presentation using electronic means (such as an electronic slide presenter) OR
2. Presentation using a poster of set dimensions to coincide with exhibition standards (a window's width and height) OR
3. Group involvement utilizing realia and tactile resources

Assessment – Performance Standards/ Rubric:

1. Rubric for Student presentations:
   90-100%: Student presents research on scientific concept in a clear, concise manner with few distractors ("um"……'uhh') and full eye contact with the audience. Slides (and or poster) will clearly show physics concept both in Silk Road context and Renaissance context. A connection to the Mongol empire will be clearly shown.

   80-89%: Student presentation will be clear and concise, yet several distractors will be observed ("um"….."uhh"). Student will have eye contact with the audience for the important aspects of the presentation. A Silk Road context as well as a Renaissance context will be shown, but the audience will have to believe in the artistic license of the presenter. A connection to the Mongol empire will be mentioned, but how the connection relates to the concept presented will need some imagination.

   70-79%: Student will successfully present topic, but there will evidence of many distractors ("um"….."uhh") and little eye contact with the audience. The connection with the Silk Road and/or Renaissance will be incomplete, or none will exist. A connection to the Mongol empire will have to be solicited from the presenter.

60-69%: Presenter will have completed the assignment, but there will be evidence that the amount of time in preparation will be low. Any connections with the Silk Road/Renaissance/Mongol empire will have to be solicited in a strenuous manner from the presenter. There may be awkwardness present from the audience members.